The Establishment of Eucalypt Seedlings in Tropical Savanna Forest

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Introduction

In wet temperate eucalypt forests, seed is released after occasional hot wild fires and seedlings germinate *en masse* in the ash bed (Mount 1969; Ashton 1976). This provides a cohort of single-aged trees that replace adult trees killed by fire. In tropical eucalypt forest, the ground layer permanently contains a mass of woody sprouts (Fensham & Bowman 1992) less than 1 m tall that are attached to lignotubers, rhizomes or root suckers (Lacey & Whelan 1976; Dunlop & Webb 1991). Germinant seedlings are a rare occurrence in most stands of tropical eucalypt forest despite annual fires (Lacey 1974; C. Dunlop, B. Wilson, pers. comm.; pers. obs.). Furthermore, seed fall of monsoon savanna eucalypts is not triggered by fire, but occurs upon fruit ripening (Dunlop & Webb 1991). These facts suggest that seedling establishment in the monsoon tropics does not conform to the model for temperate Australia.

In a study on Melville Island, Fensham & Bowman (1992) did not find any eucalypt saplings with small lignotubers, suggesting that tree regeneration does not occur from seedlings. Tree regeneration occurs when woody sprouts, with well developed underground parts, switch from a suppressed state to a sapling with relatively more continuous vertical growth. Most woody sprouts will never be trees and eventually become moribund and die. Seedlings must occasionally be recruited into the pool of woody sprouts if forest structure is to be maintained. There have been no documented studies of seedling establishment in the tropical savanna environment. This paper documents the fate of a sward of naturally occurring eucalypt seedlings for four years after germination.

Lacey (1974) suggests that a fire free period is necessary for the establishment of *Eucalyptus porrecta* seedlings in the eucalypt forest of Melville Island. This suggests that seedlings are tolerant of their own litter and the present study includes a field experiment designed to examine the allelopathic effect of eucalypt litter on seedling survival.

Methods

In the early wet season of 1987/88, a sward of *Eucalyptus miniata* and *E. tetrodonta* seedlings was located 6 km NE of Paru on Melville Island. The status of the seedlings could be assured because cotyledonary leaves were evident on most individuals. At this time, a grid comprising 24 contiguous 2 x 2 m sub-plots was marked using steel pickets (Fig. 1). Most of the sward outside the grid comprised seedlings at lower densities than within the grid, and the total sward was contained within the area represented in Figure 1. Over each sub-plot a square frame defining a smaller scale grid comprising one hundred 20 x 20 cm cells allowed the mapping

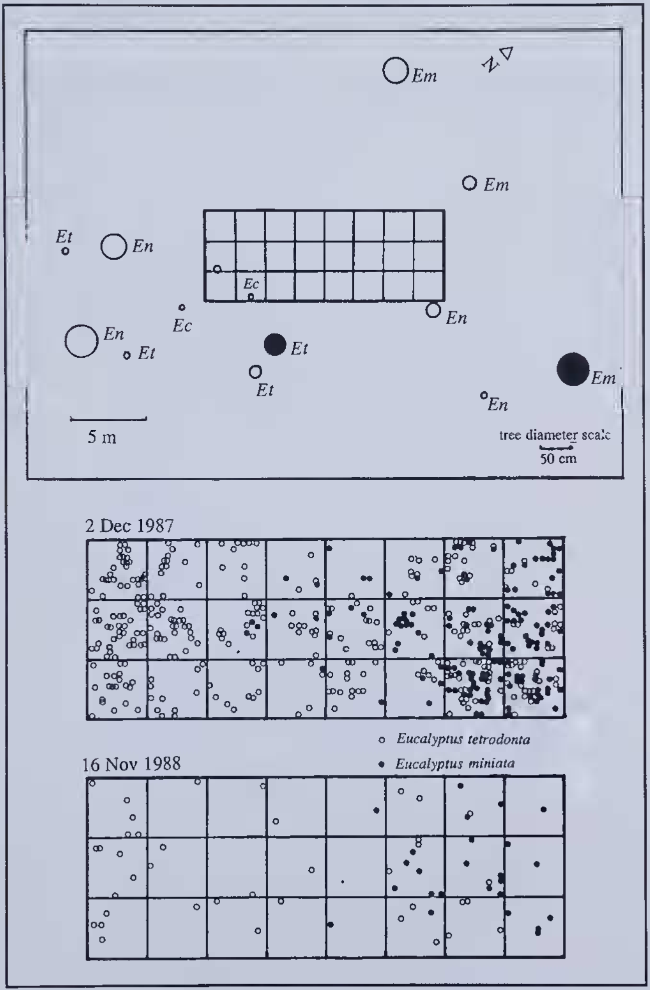

FIGURE 1 Plan of surrounding trees and germinant seedlings across the study plot at the initial and final sampling time. The mother trees of the seedlings are blacked out. *Ec*, *Eucalyptus confertiflora; Em, E. miniata; En, E. nesophila; Et, E. tetrodonta.*

of each seedling. The position and species of seedlings was noted on 2 December 1987; 7 March, 5 May, 12 June, and 16 November, 1988; and 5 January 1992. The projective foliage cover of all woody sprouts was mapped for the study grid. The diameter at breast height, height, crown radii, species and position of surrounding mature trees were noted. The plot was burnt on 30 July 1988 (mid-dry season) by a fire that incinerated all ground vegetation but left tree crowns unscorched. The plot was adjacent to a road and its ready accessibility probably assured it was burnt in most dry seasons of the recent past (Braithwaite & Estbergs 1985; Press 1988).

Twenty naturally occurring seedlings each of *E. miniata* and *E. tetrodonta* were mapped adjacent to the seedling plots. Eucalypt litter was collected in the late wet season (7 March 1988) from an unburnt eucalypt forest dominated by *E. tetrodonta* and *E. miniata* near Darwin. The forty mapped seedlings were mulched with this litter to a depth of 5 cm and radius of about 25 cm. Care was taken to ensure seedlings were not smothered by leaf litter. A further 20 individuals of each species interspersed throughout the mulched individuals were left unmulched to serve as a control, and the height and number of leaves of all plants in the experiment were measured. The seedlings were remeasured after two months and their heights and number of leaves compared between mulched and control treatments using Mann-Whitney U-tests. Mortality was compared using the Chi-square test.

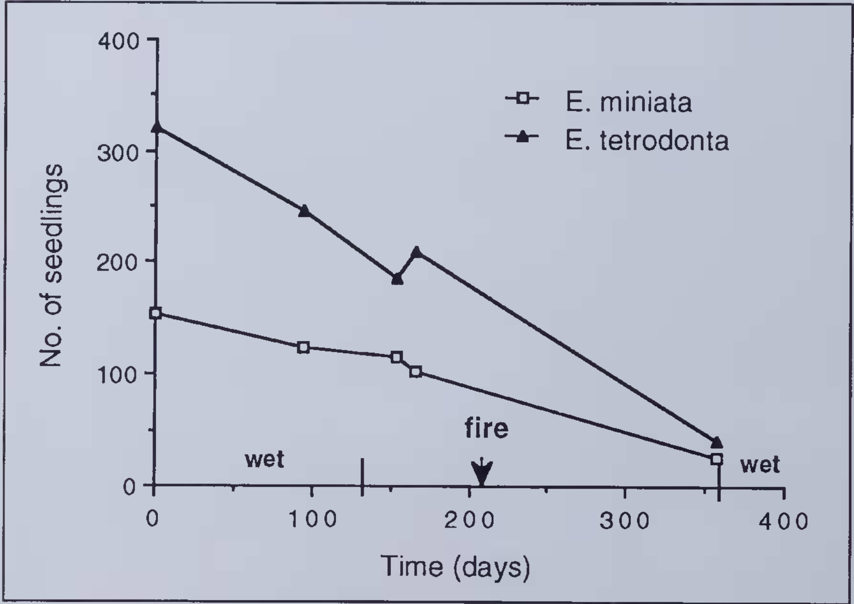

FIGURE 2 Number of seedlings within the study grid (96 m^2) for the first year after germination.

In 1992, the lignotubers of 4 year old seedlings were excavated, measured and an estimate of their size provided by the lignotuber area index (cm^2). This was calculated as the area of the minimum rectangle that could enclose their area (Fensham & Bowman 1992).

Results

Seedling Density and Survival

The *E. miniata* and *E. tetrodonta* parent trees (Fig. 1) were obvious because of the abundance of mature fruits under their canopies and the absence of fertile material on other trees in the vicinity. Their crown radii were approximately 6 and 4 m, and their heights 15 and 12 m respectively. It appears that seed can disperse at least three crown widths and 1.5 times the height of the parent tree.

New seedlings appear during the course of this study, but the mapping procedure was not precise enough for this recruitment to be quantified. Recruitment of new individuals accounts for the increased numbers of *E. tetrodonta* seedlings in the interval between the third and fourth samples (Fig. 2). This suggests that some seed remains viable after several months dormancy. A rudimentary lignotuber evident

PLATE 4 One year old *Eucalyptus miniata* seedlings. Note the ligno-tuberous swellings and deep tap roots.

on seedlings excavated in April 1998 (Plate 4) allowed some seedlings to survive fire in the first dry season after germination.

There was no apparent preferential survival of seedlings in areas of the grid where the projective canopy cover of woody sprouts was relatively low (*E. tetrodonta*: $r = 0.023$, $p > 0.05$; and *E. miniata*: $r = 0.296$, $p > 0.05$). There were only seven *E. miniata* and nine *E. tetrodonta* survivors in December 1991 four years after germination. The mean lignotuber area index for the seedlings excavated in December 1991 was 0.90 cm^2 (*s.e.* = 0.43) for *E. miniata* and 1.42 cm^2 (*s.e.* = 0.41) for *E. tetrodonta*. A selection of these excavated seedlings are depicted in Plates 5 and 6.

FIGURE 5 Four-year old *Eucalyptus miniata* seedlings.

Effect of Litter

During the 2 months between the initial and final seedling measurements of the leave litter experiment, 213 mm of rain fell at Nguiu (10 km distant). This rainfall should have ensured that litter leachates were well washed through the seedling root zone. There was no significant difference in the initial and final heights or number of leaves between mulched and unmulched *E. miniata* and *E. tetrodonta* seedlings ($p > 0.05$ in all cases). There was also no significant difference in mortality for *E. tetrodonta* (control - 15%; litter - 10%) or *E. miniata* (control - 20%; litter - 25%) ($p > 0.05$).

Discussion

The survivorship of young seedlings is difficult to determine in this study because of some seedling recruitment after the initial germination event. However, the maximum survivorship of young seedlings did not seem to be associated with low levels of woody sprout competition.

One year old seedlings of *E. miniata* and *E. tetrodonta* rapidly develop a lignotuber and a deep root system (Plate 4). These allow survival of some individuals through the inevitable fire and drought of the oncoming dry season. The underground parts of nine month old tree seedlings endured the heat of a dry season fire and regenerated new stems. The perennating organs and deep root systems allows for the rapid replacement of above ground biomass.

The evidence from this study suggests that litter leachates do not contribute to seedling mortality in situations where litter has accumulated, which is consistent with observation of Dunlop *et al.* (1975) of *E. tetrodonta* in long unburnt forest on Elcho Island.

Fensham & Bowman (1992) record woody sprouts with lignotuber area indices up to 900 cm^2 for *E. miniata* and up to 3000 cm^2 for *E. nesophila*. Lacey (1974) also draws attention to the large size of underground organs in the tropical eucalypt forest. The fact that lignotubers had only attained a range of lignotuber area indices between 0.11 and 4.16 cm^2 after four years growth (Plates 5 and 6) suggests that woody sprouts with relatively large lignotubers are of considerable antiquity. If woody sprouts survive in the ground layer for extremely long periods of time, spatially and temporally sporadic seedling recruitment such as reported in this study could maintain existing densities of woody sprouts.

PLATE 6 Four-year old *Eucalyptus tetrodonta* seedlings.

Acknowledgements

The Conservation Commission of the Northern Territory provided me with considerable logistic assistance during the course of this study and the Tiwi Land Council granted me residence on their lands. Alan Andersen and Dave Bowman are thanked for their substantial contribution to this paper as referees.

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